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TOMATO PRODUCTION IN CALIFORNIA

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Tomato growing is one of the important agricultural industries of California. In 1927, 4,491 carloads of tomatoes were shipped for table purposes; the canneries packed 2,256,878 cases of the whole tomato, and 2,166,000 cases of other tomato products, such as pulp, puree, catsup, and paste. Shipments of table stock constituted 14 per cent of the total for the entire United States, and the California-canned product was 17.2 per cent of the national total. Acreage and production fluctuate from year to year, but the tendency is for a steady increase, especially in the shipments of tomatoes for use in the fresh condition. Large quantities are grown for local markets; a considerable acreage is grown especially for seed production; and in home gardens everywhere the tomato is a crop of first importance. Thus it is seen that the tomato is grown for a number of distinct purposes in the state, each of which is of considerable importance.

The average yield in California has varied from 5.5 to 7.2 tons to the acre in recent years. While these yields are much above the average for the whole United States, greater yields are attainable with the favorable soil and climatic conditions existing in many sections of California. Yields of 10 to 25 tons per acre are frequently obtained by skillful growers. Surveys in other states have shown that the grower whose yield is below the average is likely to be losing money on the crop, while other growers in the same district whose yields are above the average, make a profit. The object of this circular is to describe methods of growing and handling tomatoes, and to point out in a general way some of the principles underlying better production. However, when the culture of such a crop as tomatoes is considered, due allowances must always be made for the diversity in soil and climatic conditions existing within the state, and the variety of purposes for which the crop is grown.

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TOMATO PRODUCING DISTRICTS

Commercial production is more or less centered in a number of important districts, each of which usually specializes on the growing of a certain type of tomato for one particular use. The earliest tomatoes are grown in the Imperial Valley. Only market tomatoes are grown in this section and they are shipped extensively to cities west of the Mississippi. About 1,000 acres are grown annually, the planting being in November and December, and the shipping season extending from early May until July. Possibly the use of a better shipping variety, or the adoption of better cultural practices, may result in the production of fruit that can be marketed successfully further east, in competition with the Florida crop.

Los Angeles, Ventura, Riverside, Orange, and San Diego counties produce a large quantity of tomatoes for canning, but most important in this district is the production of a late or fall crop for eastern shipment. From September to December, after disease has killed the plants in the southern states and frost has ended the crop in the north, there is a good demand for California tomatoes. Frost usually kills the plants in November in the southern coastal counties of California, but in San Diego and in frost-free areas elsewhere, shipping may continue to January first. For the fall crop, seed is planted in open beds in April, and transplanted to the field in June and July.

The lower San Joaquin Valley produces a considerable quantity of tomatoes, most important being the culture of early varieties for shipment, at Merced. After the shipping season ends, the latter part of the crop is utilized for manufacturing purposes. Tomato production in this section is on an extremely intensive basis and the returns by the acre are high. Canning of tomatoes is also important in Stanislaus and San Joaquin counties. The seed is sown in hotbeds just after Christmas, and the plants are set in the field about March 1, for the early market crop, while the canning crop in this district is planted somewhat later.

The Santa Clara Valley is one of the oldest and most important districts for the production of tomatoes for canning and manufacturing. In this district, as in the ones following, the sowing is done in hotbeds early in January, the seedlings are transplanted to cold-frames, and thence to the field, during May.

The San Francisco Bay district, including the Peninsula and Alameda County, is an important center for the production of canning and manufacturing stock, as well as fruit for local markets and for

shipments to the East during the fall months. Some growers contract their entire crop to a cannery, while others ship their crop when market conditions provide a profitable outlet, or when the shipping market is not good send their crop or a portion of it to the canneries.

The Sacramento Valley has several districts which produce canning tomatoes extensively. One of the most important of these is around Sacramento.

Sonoma County is an important district for cannery production. On account of the cool climate, relatively early-maturing varieties give a larger yield of ripe fruit in this region than the usual canning varieties.

There are many other localities where the crop is grown for canning and other purposes on a smaller scale. Production for local markets is more or less important in all parts of the state. Fifty-two counties in California report a commercial tomato acreage.

LOCATIONS FOR TOMATO GROWING

Before engaging in extensive tomato production, the grower must make sure that there is a profitable outlet for his crop; that is, he must have access to a good local market, to a cannery or other manufacturing plant, or be so situated that he can ship to advantage. It is generally not advisable to grow the crop for shipment unless the acreage is large enough to make carload lots possible, either by the individual grower or by groups or associations of smaller growers located in the same community. The season at which the crop will mature and the probable market conditions existing at that time should be carefully considered.

The tomato is a heat-loving plant and the long growing season in most parts of the state is very favorable for tomato production. Localities subject to late spring or early fall frosts, or with very cool summer climate, are not suitable for the crop.

As to type of soil, the tomato is not particular, though this factor may influence yield, quality, and time of maturity to some extent. Sandy soils favor an early maturing crop, while heavier soils are especially suited for late maturing or fall crops. Muck or peat soils, though usually considered unsuited to tomatoes, have been observed to produce excellent crops of good quality when the moisture supply was not excessive (fig. 1). Good drainage is always essential. Soils that are too moist for any considerable period during the growing season usually produce a poor crop, because of excessive vine growth

and a poor set of fruit. Soils that are excessively rich in nitrogenous matter may produce a similar effect. Other crops than the tomato may make more profitable use of the fertility provided by plowing under an alfalfa sod. The tomato will root deeply unless prevented from it by plow sole, hardpan or poor drainage. The history of the land from the standpoint of alkali content, and nematode- and wilt-infection, is also important, for the tomato is very susceptible to injury by these things.

Fig. 1.—Tomatoes as an intercrop in an asparagus plantation, the first year. This was on well-drained peat soil at Terminus, California. The tomatoes were of good quality.

CROPPING SYSTEM

A large part of the tomato crop in northern and central California is produced in rotation with a winter crop of spinach. The tomato plants are pulled and burned after picking is finished in November; the land is fitted and sown to spinach at once. The spinach crop is harvested in March and April, and the land is prepared for tomatoes again, the plants being transplanted during May. This combination is a good one, but may lead to bad results if the same land is continuously cropped in this way. Tomatoes should not be grown more than once in four years on the same piece of land; they should be grown in rotation with other crops. Certain diseases and insects often become prevalent and do much damage when tomatoes are grown

continuously. The double-cropping of land with winter vegetables and tomatoes is practicable only when the tomato crop can be irrigated.

That tomatoes exert an injurious or poisonous effect upon subsequent crops, is an idea held by some growers, but which is not founded upon fact. When the dead tomato vines are plowed under, they have a beneficial effect. However, when they are piled and burned, the accumulation of ash in these spots may be injurious to the next crop.

Fig. 2.—Tomatoes as an intercrop in a three-year-old peach orchard at Merced. Though the trees are 24 feet apart, there is room for only two rows of tomatoes. Competition for water between trees and tomatoes will be severe, requiring heavy irrigation. The shade of the trees reduced loss from yellows disease in the tomatoes.

Tomatoes are extensively grown as an intercrop in young orchards (fig. 2), to which purpose they are well adapted when the irrigation practice for tomatoes does not conflict with the requirements of the trees. This may sometimes be an objection, especially in young walnut groves. Deciduous fruit orchards should not be intercropped with tomatoes after the third year.

VARIETIES

The choice of a suitable variety of tomato depends upon the use for which the crop is intended, the climate of the locality, the season of year at which it is to be marketed, and the presence or absence of certain diseases to which the variety may be susceptible. Many

varieties have been developed which are early in maturing, but they may or may not be suitable for shipping, and are generally too small to be suitable for canning. Other varieties are too large or too rough for fresh-fruit markets, but have qualities which make them suitable for manufacturing purposes. To get high quality seed of a variety adapted to local conditions and uses, is important. The cost of good seed is only a small item, for one pound will produce enough plants for 25 acres of canning tomatoes. In the following list is described a limited number of varieties, which have been found satisfactory for one or more purposes in California.

Earliana.—Several rather distinct improved strains of this variety are now available, such as North Dakota Earliana, Morse's Special Early, Alacrity, Burbank, King of the Earlies, and others. The original Earliana was a flat, rather rough tomato, but the improved strains just mentioned produce mostly smooth, globular fruit. The plants of Earliana are comparatively small and weak-growing, requiring only one-third as much space to the plant as late varieties. The fruit is red, early in maturing, but small compared with late varieties. Earliana is an excellent variety for extra-early crop for growers catering to a local market. It is also used to some extent for spring shipments.

Globe.—The fruit is purple, round to slightly elongated in shape, somewhat larger than Earliana, and is about two weeks later in ripening. Globe has long been the standard shipping variety of Florida and the Gulf States, but is little used in California.

Marglobe.—This variety was introduced a few years ago by F. S. Pritchard of the United States Department of Agriculture. It was the result of hybridizing the Marvel and Globe varieties, followed by selection for the Fusarium wilt resisting quality of Marvel, and the shipping quality of Globe, which characters it combines to a satisfactory degree. In addition, it possesses considerable resistance to nailhead spot (*Alternaria*), a serious disease in some sections outside of California. Largely for this reason, Marglobe is being used extensively in the southern states and in Mexico. The fruit is round, red, of medium size, of good shipping quality, and medium early. It has proven satisfactory in Imperial Valley, and in southern California for fall shipping.

Stone.—This variety is usually classed as "late," the fruit ripening nearly a month after Earliana, but about two weeks earlier than San Jose Canner and related canning varieties. The plants are likewise intermediate in size, between that of the foregoing varieties. The

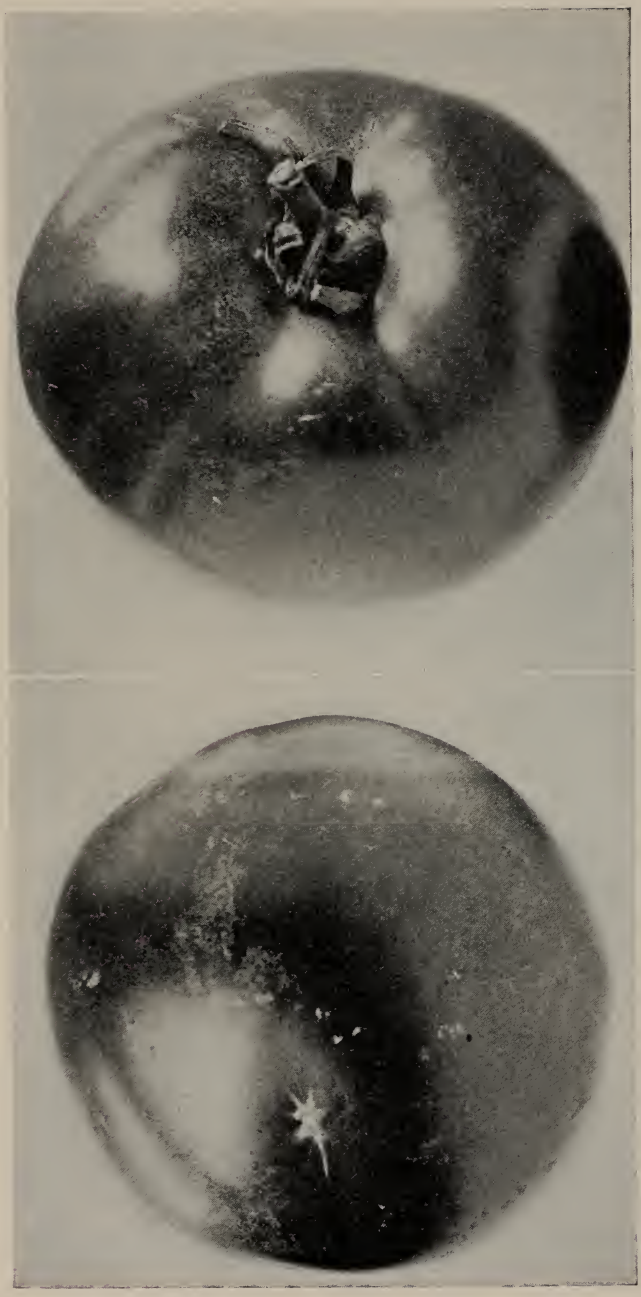

Fig. 3.—Fruit of the Stone or Norton variety, showing the smoothness at stems and blossom ends, and freedom from blemishes. (From Agr. Exp. Sta. Circ. 280.)

fruit is red, slightly flattened, generally smooth and free from "cat-faces," and is of medium to large size (fig. 3). Stone is much used as a dual-purpose variety, for late shipping and for canning, in the Los Angeles district. It is also a fairly satisfactory variety for fall shipment in central and northern California. While its smoothness commends it to the canner for putting up a "solid pack," the fruit of this variety tends to be too small for economical canning crop production, except where the soil is very fertile and moist, or where the growing season is too short or too cool to permit of growing the larger canning varieties.

Norton.—This is a strain of the Stone, which is highly resistant to the Fusarium-wilt disease. This does not imply resistance to other troubles. It was introduced by F. S. Pritchard, of the United States Department of Agriculture, in 1918. That Norton is wilt-resistant has been well demonstrated in Los Angeles, Riverside, and San Diego counties, and as it is in all other respects practically identical with Stone, it should be grown wherever a variety of the Stone type is desired.

Morse's Canner.—Although originally selected for canning purposes, this variety is now more important for the late market crop. The plants and the fruit in general resemble Stone, but the fruit is considerably larger, and is generally smooth, red in color, globular or slightly flattened. This variety probably produces the largest tomatoes of any smooth fruited variety. The large cells, and failure to color evenly, are said to be its main defects from the canner's viewpoint.

Italian Stone or Quartinino.—These names are usually applied to a medium-early variety, grown chiefly in the Merced district and entirely distinct from Stone. When not pruned to a single stem, the plants assume a very distinct compact semi-erect type of growth. The fruit is more completely protected from the sun by the dense foliage, than in any other variety. The fruit is red, flattened, medium in size, inclined to be rough or corrugated, and is more acid than usual in flavor. The improved strains of Earliana have been found to be considerably superior to it in earliness and in production of U. S. No. 1 grade fruit.

San Jose Canner.—This name is generally applied to a large, rather rough, and late maturing variety, widely used for the canning crop in central and northern California. Santa Rosa, Diener, San Felipe, and Jap Canner are other names applied to this variety, or to certain growers' strains of it. Santa Clara Canner is an improved

strain of the Canner type, developed by C. C. Morse and Company. Cal. No. 1, Cal. No. 55, Caleven, and Calpac are other strains introduced by the California Agricultural Experiment Station, and are the result of several years' selection by J. W. Lesley and J. T. Rosa, for a smoother, more uniform type than the original variety.

The original San Jose Canner variety was probably derived from Trophy. It has very large fruits, much flattened in shape, and many of them have a deep corrugated depression at the stem end and a large irregular scar at the stylar or "blossom" end (fig. 5). These defects cause a high percentage of waste in preparing the fruit for canning.

Fig. 4.—This shows the varying degrees of roughness and corrugation at the stem end in the old types of the San Jose Canner variety. (From Hilgardia, vol. 2, no. 2.)

However, the fruits possess a high degree of solidity and an excellent color, which commend them strongly for canning. Furthermore, the large size of fruit and the heavy yield, makes this variety an economical one to grow and to harvest. The improved strains (fig. 6) are in general much smoother and more uniform in shape than the original type, while retaining the large size, solidity, and color of the parent. The solidity is in part due to a tough epidermis, in part to the large meaty core, and the numerous small cells or locules, with thick radial walls. Some of the improved strains are much earlier in maturing than others.

Trophy. (Alameda Trophy).—The variety grown under this name in California is different from the original Trophy variety. It is much used for making catsup and other manufactured products, especially in Alameda County, but the fruit is too rough to permit of canning it economically. The fruit is medium to large, flattened, usually very rough or corrugated, and resembles the San Jose Canner in internal structure. The deep red color of the pulp is partly a varietal characteristic, and partly a result of the non-irrigated condition under which they are grown in Alameda County. Trophy is earlier than most strains of San Jose Canner, and in cool regions is more productive.

Italian Varieties.—Much interest has been aroused in the United States in recent years concerning certain Italian varieties, due to extensive imports of canned tomatoes and tomato products from that country. The Italian varieties most suitable for a solid pack, of small whole fruit used for salads, are Princess Borghese and King Humbert. The fruit of these varieties is about twice as large as the common Red Pear, but smaller than Earliana. They are of superior color and solidity. They are elongated in shape, with only two cells, and are borne in large clusters. Some Italian varieties, especially the Humbert, have a higher content of solids than American varieties, which is a valuable feature from the manufacturer's viewpoint. Princess Borghese, however, has a rather low solid content. An outstanding characteristic of these tomatoes is their ability to remain on the plant, sound and firm, for weeks after they attain full color. Their moisture content does not change appreciably during this period. The main objection to the growing of such varieties is the high cost of picking the small fruits. This is partly balanced by the fact that only a few pickings are necessary, as the fruit can be left on the plant until a large part of it is ripe. Other Italian varieties tested at Davis are inferior in size, uniformity, and yield, to the ordinary California types.

GROWING THE PLANTS

For the sake of economy of seed, earliness, and convenience in growing the crop, the plants are usually grown in beds of one kind or another, from which the plants are transplanted to the field at the proper time in spring, usually after danger of frost is past. The best method of growing the plants depends on the locality and the season at which the crop is desired.

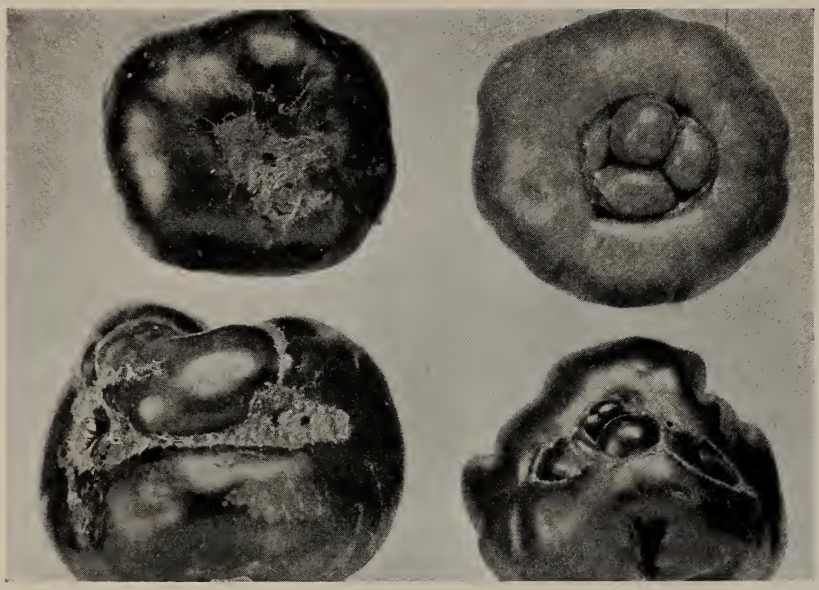

Fig. 5.—This shows the irregular or rough blossom ends, with large stylar scar, which is commonly found in the old types of San Jose Canner variety. (From Hilgardia, vol. 2, no. 2.)

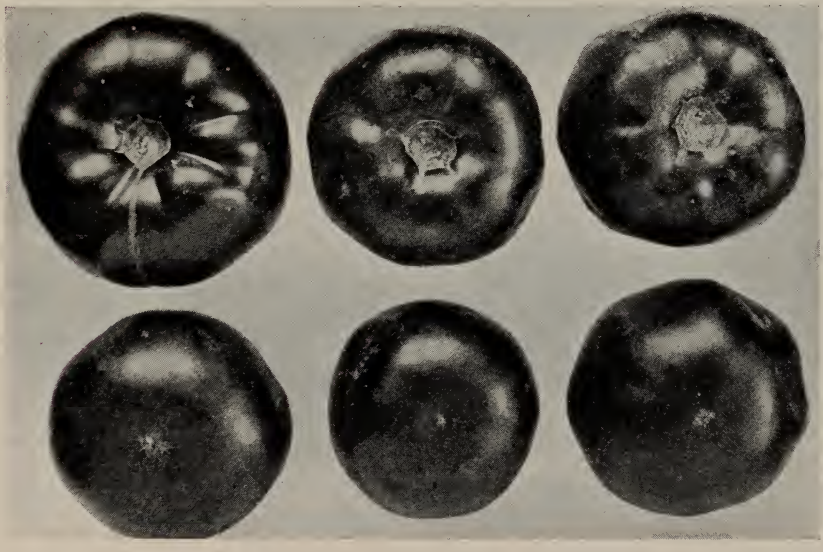

Fig. 6.—View of the fruit from an improved strain of San Jose Canner variety, which has been selected over a period of years for smoothness and large size. (From Hilgardia, vol. 2, no. 2.)

The Hotbed-Coldframe Method.—The hotbed-coldframe method is generally best for early market crops, and is also used even for the late shipping and canning crop in central and northern California. This method is described in detail herein, because its more extensive use seems desirable. The hotbed frame should be located in a warm, sunny, well drained spot. The best covering for the hotbed is glazed sash, but unbleached muslin (grade DD) is also satisfactory, especially if treated with a waterproofing compound. About one foot of fresh, hot, horse manure is placed in the bed, tramped down, and a layer of soil four inches deep placed over this. It is best to use a sandy soil or a mixture of one-half sand and one-half garden soil in the hotbed. This gives stronger plants, with better root systems, than does a very fertile or heavy soil. The seed usually is planted early in January, three months or more before time of field setting. It is sown broadcast, or drilled into rows about four inches apart and covered about one-half inch deep. If good seed is sown is sown at the rate of 12 or 15 per inch of row, one hotbed 6 by 24 feet in size should produce about 50,000 seedlings. The hotbed should be kept warm and moist until the plants are up, after which time it should be well ventilated during warm days, and watered sparingly.

As soon as the seedlings show their first rough leaves, they are ready to transplant to another bed, usually a coldframe (fig. 7). This is a task that is worth doing well and carefully. The coldframes are prepared much like the hotbeds except that no manure is placed under them. A suitable covering for the frames may be made of unbleached muslin sewed together in sheets, or tacked on to frames of convenient size for handling. About four inches of fine soil should be placed in the coldframe, preferably a mixture of one part garden soil, one part sand, and one part rotted manure, all well mixed and passed through a screen of one-half inch mesh. The seedling plants from the hotbed are set in the bed about two by four inches apart usually.

Watering should follow transplanting and the frames are kept covered a few days, until the plants have taken root. This is especially necessary if the sun is warm or the weather windy. After the plants have begun to grow, the frames should be ventilated freely during the daytime, and watered only enough to keep the plants growing at a moderate rate. When the plants are about ten inches high, the beds should be gone over and the terminal bud pinched out of each plant. This prevents the plants from growing any taller and encourages the development of thick, stout stems and good root

systems. At the same time, shoots begin to develop in the axils of the leaves. In this manner, the framework for a large bushy plant is started before the plants are set in the field. This treatment of "topping" the plants two or three weeks before transplanting to the field has been found, in experiments, to result in considerable increases in yield of early fruit.

Fig. 7.—The type of coldframes used for plant growing in central and northern California. They are 8 to 12 feet wide; the sides and ends consist of 1 × 12 inch boards; and the frames are covered with sheets of unbleached muslin. The seedling plants from the hotbeds should be transplanted into these coldframes, about 3 inches by 4 inches apart. (From Agr. Exp. Sta. Circ. 280.)

A variation in the hotbed method as described above is to transplant the seedlings into small clay pots or into "dirt bands" from which the plants can be transplanted without disturbing the roots.

Although more expensive, this method may be profitable to the market gardener who caters to a demand for extra-early fruit on a local market. Another method is to transplant the seedlings to "flats," boxes about 18 by 24 inches in size, and 3 inches deep. This is a satisfactory way to grow plants for sale, as is done by many gardeners and seedsmen.

For a week or ten days before transplanting the plants to the field, the beds should be left open day and night, unless frost threatens, and only enough water applied to keep the plants from prolonged wilting. This treatment toughens or "hardens" the plants so that they will stand transplanting without severe wilting, which so often kills tender plants when set in the open field. Well-hardened plants are slightly more resistant to frost than soft succulent ones, and they also take root and begin to grow more rapidly.

The Coldframe Method.—Tomato plants may be started in coldframes where they have to be sown during cool weather but not so early as to require the hotbed method. Frames are prepared running east and west in a sheltered sunny spot. A four-inch layer of sandy, moderately fertile soil should be placed in the frames. The seed is sown by hand or with a seed drill, being planted thinly in rows four to six inches apart. After germination, the beds should be weeded and the plants thinned to about three plants to the inch. This method can be used to produce large numbers of plants cheaply, but good large stocky plants with well-developed roots are seldom grown in this way, the seed being usually planted too thick and the growers failing to do the necessary thinning. The plants are pulled and transplanted directly to the field from the coldframe.

The Open Bed Method.—This is probably the cheapest way to grow plants but it is not adapted to sections having short growing seasons, nor to early crop production. It is used for growing plants for the late shipping crop in southern California, and may also be suitable for late market crops elsewhere, when relatively quick-maturing varieties like Marglobe and Norton, are used. For the open bed method, beds are prepared in a well-drained sheltered spot, preferably where the soil is sandy. Narrow beds, thirty to thirty-six inches from center to center, are thrown up with a lister, the ridges are harrowed down and levelled with a planker, and two rows are sown on each bed. The furrow between the beds is used for irrigation. The seed is drilled in with a seeder as soon as the soil warms up and danger of frost is over. It is very important to see that the seed is not planted too thickly even in these open beds, and thinning should be practiced where the plants stand too thick.

Care of Plant Beds.—Plant beds, whether covered or open type, must be weeded and cultivated to prevent crust formation around the plants. Thinning the plants is often necessary, for if crowded they develop weak spindling stems, resulting in plants of very poor quality. Particular care should be given to the watering of plant beds, for overwatering results in weak, sappy, leggy plants that are hard to transplant to the field and which recover slowly if they survive transplanting. Excessive moisture, especially if given late in the day, encourages "damping off," a disease which sometimes destroys many

Fig. 8.—This shows the more rapid growth of plants from seeds sown directly in the field on May 1 (at the left), compared to plants of the same age but transplanted from a seed bed (at the right). The difference in size of plants gradually disappears later in the season. Photographed June 18, at Riverside. (Courtesy of M. Shapovalov.)

plants overnight. Waterings should be given usually several days apart, and not until the plants have begun to wilt. No harm is done if the plants are checked temporarily by lack of water. However, holding plants for a long period after they have reached transplanting size is undesirable. For this reason, it is advisable not to plant earlier than necessary to get plants of the correct size for transplanting at the desired time. Ten to twelve weeks should be allowed for plant growing.

The day before transplanting to the field, the beds should be soaked well so that the plants can be removed easily. In taking up the plants, it is better to dig them with a spade, rather than to pull by hand, which is the too general practice.

Seeding Directly in the Field.—In sections having a long season, tomatoes may be planted directly in the field. This method is wasteful of seed, involves considerable labor in thinning, and cannot be practiced when tomatoes follow a winter crop of spinach or other vegetables. On the other hand, direct field planting saves the cost of hotbeds and of transplanting, and the growth of the plants is not delayed by the transplanting process (fig. 8). It is a cheap way to produce an excess number of plants, where there is danger of loss from the yellows. Non-transplanted tomatoes also develop a deep

Fig. 9.—The root systems of tomato plants. The one at the left was transplanted from the hotbed. It has no taproot, but does have a number of shallow laterals. At the right is shown a plant from direct field planting. It has a long taproot, and the laterals are deep.

tap root (fig. 9), which gives them an advantage under dry-farming conditions. Only varieties that mature in a medium or short season should be grown this way, unless the season is very long. The seed is planted in hills early in March before danger of frost is over. Later, the plants are thinned to two in a hill. At Davis, about the same yields of ripe fruit were obtained from field-planted and from hotbed-grown plants, in two years' tests.

In the Imperial Valley, almost the entire acreage is ordinarily grown from November plantings made directly in the field. They are protected with brush and paper shelters, as shown in figure 10, until danger of frost is past.

FIELD CULTURE

Except where following spinach or other winter crops, tomato land should be fall-plowed as deeply as possible. In spring, before the surface gets hard and dry, the land should be disked and floated to kill weeds and to get the surface into fine condition, and level. The method of preparing for the plants and method of transplanting depends upon the locality and the soil conditions. In some sections, when planting for the early crop, it is easy to set the plants without watering if the soil is handled properly. Under such conditions, the field is prepared level and marked off in both directions and the plants

Fig. 10.—Method of protecting tomatoes sown directly in the field, in Imperial Valley. The seed is planted in hills on the south side of beds running east and west. Thinning is deferred until danger of frost is over, in February.

set at the intersections, if they are set by hand. In setting large acreages, however, much time and labor can be saved by the use of a horse-drawn transplanter. These machines, of which there are several types on the market, set the plants as well as they are usually set by hand, and can be used also to water the plants, if necessary.

In dry sections, and in most sections during dry seasons, it is necessary to water the plants as they are transplanted. This is almost always the case in setting the late crop. If irrigation is practicable, the simplest plan is to plow out a furrow for each row. The plants are set the proper distance apart on the edge of the furrow and a small stream of water is turned into each row as it is set. Cultivation must follow within a day or two to prevent a hard crust forming around the roots. At this time the soil should be worked toward the plants, thus beginning the bed which should be gradually formed for each row.

Another way to set plants under dry conditions is to haul a number of barrels of water into the field and place them at convenient intervals. As the plants are set, a little water is poured about the roots.

In transplanting tomatoes, the roots should be covered as deeply as possible, usually setting the plants three or four inches deeper than they were in the plant bed. New roots develop along the stem, giving the plant a more extensive root system than can be obtained when the plants are set shallow. Deep setting is of course more laborious than the customary shallow setting, but it enables the plants to make use of the moisture in the lower soil. Deep plowing, or sub-soiling also aids in securing deep penetration of the roots. Plants with deep roots are most assured of an even moisture supply, do not require so frequent irrigations, and do not suffer from the sharp fluctuations of alternately having too much and too little water. Some of the troubles affecting tomatoes result from too shallow root systems.

Irrigation.—In some parts of the state, satisfactory tomato crops can be grown with little or no irrigation, if the plants are given a chance to develop deep root systems. This is true of the San Francisco Bay and other cool regions with over 15 inches of winter rainfall. However, in most sections some irrigation gives larger yields. The number and frequency of irrigations is determined mostly by local conditions. Enough water should be applied to keep the plants growing steadily. Too frequent irrigation may favor excessve vine growth and sometimes causes the blossoms to drop without setting fruit. The best method is to open a furrow alongside each row (fig. 11), as close to the plants as possible, so that the moisture can seep down to the roots. Cultivation should follow promptly, throwing the soil toward the plants. For each successive irrigation, the furrow is made further from the plants and by mid-season a broad low bed has been formed, which is covered by the sprawling plants (figs. 12 and 13). Between the beds is the dead-furrow which may be used for later irrigations, allowing the water to penetrate to the roots without wetting the surface on which vines and fruit are resting.

The first irrigation after the one given at transplanting time, should usually be deferred until after the plants have begun to set fruit. The number and frequency of the irrigations thereafter depends upon soil and climatic conditions. On heavy soils in the Sacramento and Santa Clara Valley, three irrigations, of four or five acre-inches each, may suffice for the entire season. On lighter soils in the San Joaquin and Imperial Valleys, where evaporation is very high, an irrigation may be necessary every two weeks.

Fig. 11.—Tomatoes furrowed for the first irrigation after transplanting. Fruit setting has already begun on these plants.

Fig. 12.—Irrigation of tomatoes from slip-joint pipe. By the use of a V-crowder, a basin two feet wide has been made between the rows. This is advisable where the land slopes very steeply. As the lateral movement of moisture is negligible, a furrow close to the plants, however, would be more effective. After a run of six hours, the moisture had not penetrated more than six inches to each side of this basin.

There are two periods at which water generally should not be applied—during the period when the first flowers are open, and during the later part of the fruit-ripening period. Irrigation at the earlier period will decrease the set of fruit, and at the later period may retard the maturing of the crop. However, in some sections where the crop is grown for late fall shipment, the practice is to irrigate just as the first cluster begins to bloom. This prevents the setting of early fruit and may encourage the development of a larger plant that will produce more late fruit.

Fig. 13. Tomatoes furrowed for late irrigation. There are plenty of tomato roots in the row middles at this time.

Planting Distances.—The planting distance is determined by the variety, the soil, and the season at which the crop is grown. Early tomatoes grown under intensive culture, where the plants are staked and trained to a single stem, as in the Merced district, are set 15 inches by 3 feet apart, thus requiring about 12,000 plants per acre. Early varieties where not staked and pruned, are usually set about 3 by 4 feet, requiring 3,600 plants per acre. The late shipping and canning crop of such varieties as Stone, which generally make vigorous vine growth, are set 6 by 6 feet, and the San Jose Canner requires 6 by 8, to 8 by 8 feet. The late varieties then require from 700 to 1,200 plants per acre. Further modification may be necessary on account of moisture and fertility conditions. Under dry-farming conditions, wider spacing is desirable than under irrigation.

Wider spacings are more economical of plants and labor than the closer plantings. Yet there are no reliable data available to indicate when wide or close plantings will pay best. Certainly the rows must be wide enough to allow cultivation and irrigation and to permit easy passage for the pickers without tramping upon the plants. Experiments in which two plants are set in a place show slightly less yield from the two than from a single plant.

STAKING AND PRUNING

The tomato plant naturally forms an erect central stem, with side branches developing from the axil of each leaf. Under the special form of culture known as staking and pruning, the side shoots are pinched out as they appear. The growth is thus limited to the main or central stem, which is kept erect by tying it at intervals to a stake placed alongside each plant as shown in figure 14. On such plants, the crop is limited to the fruit born in the clusters which form at every third or sixth node on the central stem. Naturally, this reduces

Fig. 14.—Staked tomatoes, at about the time the first cluster is ripening. The lower leaves have been cut off, to expose the fruit to the sun. The plants may also be topped above the sixth cluster at this stage.

greatly the number of fruits that a plant can bear, but this is partly offset by the closer spacing of the plants which this method of culture permits. Plants to be staked and pruned may be set 15 to 18 inches apart in rows 3 feet wide. This gives three or more times as many plants per acre as an early variety grown without staking and pruning. It is claimed that staking and pruning results in increased earliness, greater production of early fruit, and larger fruit, than do plants allowed to grow naturally. On the other hand, staking and pruning results in higher costs of production per acre for labor, plants, and materials. This treatment may result in increased loss

from mosaic and from blossom-end rot diseases. Furthermore, under California conditions it gives a lower total yield for the season, and the increase in early production may be more apparent than real, when considered on the basis of yield to the plant, rather than on that of yield to the acre. The staking and pruning method of culture should be limited to home gardens and to early-market crops when the area available is very limited.

FERTILIZERS AND MANURES

The tomato crop in California is generally not manured or treated with commercial fertilizers. There is very little experimental work to guide fertilizer practices with this crop on our soils. It is evident, however, that upon most soils, and in most localities in the state, tomato plants make satisfactory vegetative growth and produce large crops of fruit, without artificial fertilization, when moisture and other factors are properly cared for. An exception to this may be found on some of the light sandy or gravelly soils in the southern part of the state, where it has been found that tomatoes respond with increased growth and larger yields, when nitrogenous fertilizers are applied. In cases where the plant growth is unsatisfactory, the cause should first be sought by determining if injury is being caused by hardpan, poor drainage or irrigation, alkali, or disease. The history of the soil, whether or not other annual crop plants grown on it respond to fertilizer applications, may also serve to indicate the requirements for tomatoes. Two common misconceptions about the fertilization of tomatoes, namely, that the injurious effects of too much nitrogen can be overcome by adding more of some other element, and that potassium fertilizers have some particular effects upon solidity and shipping quality, have been disproved.

Where a commercial fertilizer is to be used, the best method of applying it, usually is to drill it into the row where the plants are to go, and mix it with the soil before the plants are set. A fertilizer is generally most effective if it is placed where the roots will obtain it in the early part of the growing season. When the soil is deficient in nitrogen, the cheapest and most effective form in which it can be supplied, under California conditions, is in ammonium sulfate. Three hundred pounds per acre of this material is usually a maximum application.

HARVESTING

The exact stage of maturity at which the fruit is picked depends upon the purpose for which it is to be used.

For sale on local markets, for canning, and for pulp manufacture, the fruit should be fully colored but firm when picked. Nothing is gained by leaving the fruit on the plant after it is fully colored.

For shipment to nearby points the fruit is harvested in the "pink" stage, when about half of the surface shows distinct color.

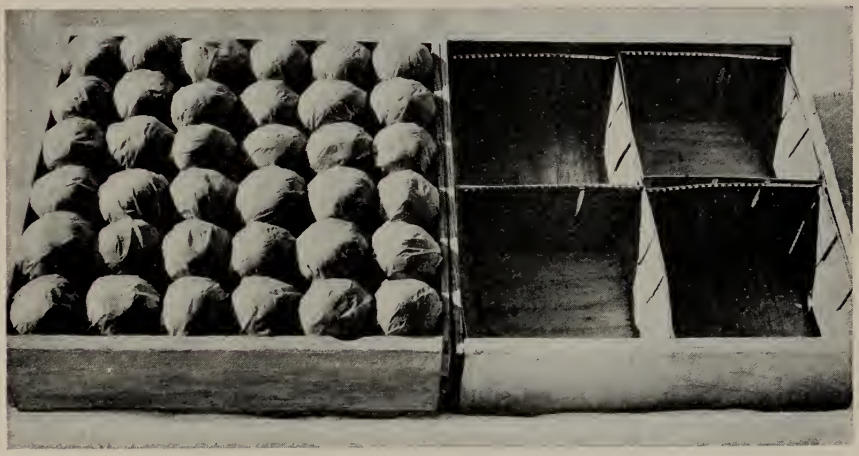

Fig. 15.—Tomatoes wrapped and packed in "tin-tops." Baskets hold about five pounds each and are shipped in four-basket flats. This package is suitable for early market tomatoes, shipped in the pink or ripe stage, to nearby markets. (From Agr. Exp. Sta. Bul. 239.)

For shipment to distant markets, the fruit is picked usually in the "green-mature" stage—when fully grown but not yet showing pink or red color. Such fruit should, however, appear yellowish at the blossom end. Mature green fruit if cut open are found to have the cells well filled with the gelatinous pulp in which the seed is embedded.

To pick tomatoes for shipment, the fields are generally gone over once a week, and fruit in all of the above stages of ripeness gathered at once. The ripe fruit, however, is placed in separate containers by the picker, and is disposed of on the local market or to the canner. The pink, turning, and green fruit is hauled to the packing shed, where it is sorted, graded, wrapped, and packed for shipment. This part of handling the crop can generally be taken care of through a

local cooperative packing and shipping association, or by a reputable distributing organization, better than by the individual grower.

Great care should always be taken in handling tomatoes for any or all purposes, to avoid bruising or breaking the skin. The pickers should remove the stem from the fruit as it is picked, to prevent puncturing the skins of other fruit.

Packing.—Persons interested in the packing and shipping of tomatoes shoud secure Farmers' Bulletin 1291 from the United States Department of Agriculture, Washington, D. C. The two types of containers most used in California are the four-basket flats, shown in figure 15, and the Los Angeles or Mexican lug, figure 16. The latter is used mainly for eastern shipments. Cannery tomatoes are handled in 50-pound lug-boxes, which are supplied to the growers by the canners at a nominal rental.

Artificial Ripening.—Fruit picked in the green-mature stage ripen and color up within one to three weeks, depending upon the temperature and the degree of maturity when picked. The quality of such fruit is good when ripened in air, but when wrapped in tissue paper, as is the usual commercial practice, the flavor and texture of the artificially ripened fruit may be unsatisfactory. Upon arrival at market, the fruit is unwrapped; that showing sufficient color is sold at once, while that which is still green or only partly colored is placed in special ripening rooms. Another defect in the practice of picking and shipping green-mature tomatoes is that careless pickers gather many that are not mature. The latter are worse than a dead loss to the grower, for they never attain good edible quality when artificially ripened. Tomatoes picked in the "turning" stage, when they show a little pink color at the blossom end, are more uniformly of high quality when artificially ripened, than those picked green.

The most favorable temperature for rapd ripening of tomatoes is between 70° and 80° F. Below 60°, the ripening process is very slow. The maximum storage life of the tomato is obtained with a temperature between 50° and 55° F. If stored at temperatures below 50° F for more than a few days, the fruit does not color, but decays upon removal to a higher temperature. Prolonged cold storage of either green or ripe tomatoes is therefore impracticable.

The ripening of tomatoes in storage can be greaty accelerated by adding small amounts of ethylene gas to the air of the storage room. A concentration of one part ethylene to 4,200 parts of air has been found effective, reducing by about one half the time required to change

tomatoes from the green to full red color. The gas is obtained in compressed form in steel cylinders, from which the proper amount of gas is discharged into the ripening room each day. The room has to be approximately airtight to prevent the too rapid loss of the gas.

Fig. 16.—A tomato packing room, showing convenient arrangement of grading bins, movable packing tables, box chutes, and conveyors for the packed boxes. At the right are packed 30-pound Los Angeles lug-boxes. This package is used for shipment of green fruit to distant markets, where the fruit is unwrapped, sorted, ripened, and repacked in smaller containers for retailing. (Courtesy of R. G. Risser.)

Oxygen is also essential for normal ripening, so a fresh supply of air should be admitted each day. Temperatures favorable to the ripening process have to be maintained in the ripening room, even when ethylene is used. Ethylene is explosive in mixtures of 1 to 3 in air, but is not dangerous or explosive in the low concentrations used in ripening tomatoes.

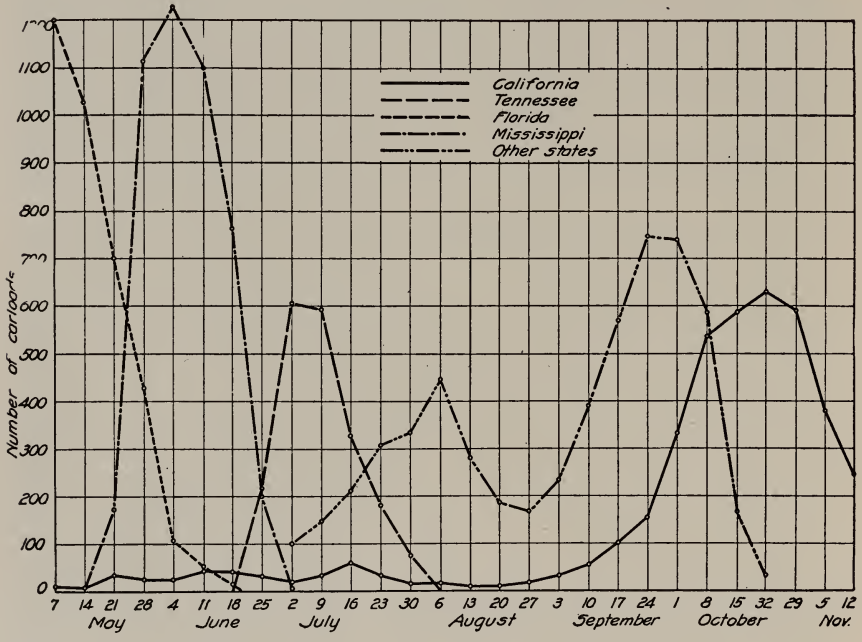

Fig. 17.—Carlot shipments of tomatoes from the chief shipping sections, by weeks, for the season of 1927. From December to May, the markets are supplied almost entirely by Florida and Mexico.

SHIPPING SEASONS

To make clearer the opportunities for tomato production for shipment to outside markets, and to show the relation of tomato shipments from California to those from other sections and from the United States as a whole, the carlot shipments from the leading tomato districts are shown in figure 17. While minor changes in volume and season occur from year to year, the general shipping cycle remains about the same.

Tomatoes are shipped throughout the year, but from December to May the markets are supplied almost entirely by Florida and Mexico. Shipments from other sections gradually increase during the spring

until a peak is reached in June. Thereafter, they decrease and the total number of cars shipped during July and August is relatively low. This is the period of local production in the North and East, so that carload shipments from outside districts are not needed. Late in August the market on tomatoes improves, due to exhaustion of home-grown supplies in the East and South. This leads to a second peak of shipments during the fall, which declines rapidly as frost cuts down one shipping section after another. By the middle of December the only shipments of any importance are those from Mexico. It is noted in figure 19 that shipments of early tomatoes in California are not very important, due to heavy production in other sections nearer the big markets of the country. However, after the first week of October, California is the only important shipper of tomatoes. For a period of two months in the fall, California tomatoes have command of the markets of the entire country. Production for shipment in this period seems especially promising.

SEED GROWING

Comparatively few tomato growers now select and save seed for their own use. Yet it is often well to do this, and do it carefully, in order to develop an improved, acclimated strain.

Although tomatoes are very largely self-pollinated, some crossing does take place when different varieties are grown near each other. The amount of crossing varies from 0.2 to 5 per cent, depending upon the variety and on the number of insects (mainly bumble bees) which visit the flowers. Accordingly, the seed plot should be isolated from other varieties.

Many varieties contain plants varying a great deal in vigor and yield, as well as in quality and type of fruit. Some seed stocks are actually mixed, containing plants of poor type or low yield or of different varieties. The procedure recommended is to mark certain plants that show vigor, health and earliness, about the time the fruit begins to ripen. The pickers are then instructed to take no fruit from the marked plants. A second inspection, two or three weeks later, will enable one to judge of the productivity, quality and type of fruit. The fruit should have desirable internal characteristics (fig. 18, *A*). and should not show the "puffy" condition (fig. 19). The plants which seem desirable from this standpoint are retained, while the other plants marked at the first selection are discarded. It is best to save separately, and to plant one row in the field the next year with seed from

each of the selected plants. The rest of the seed from the selected plants can be mixed and used for the main planting. From the best row the next year, seed is saved in sufficient quantity for the entire planting the third year. Practically all of the benefit derived from selection is apparent in the tomato the first year after selection is made. Selection simply isolates the best qualities present in the original variety, and the improvement over the average is usually sufficient to make the practice quite profitable. However, selection should be continued from year to year to eliminate any degenerate plants and to preserve and improve, if possible, the qualities of the original selection. Indiscriminate selection of good fruits without reference to vigor, health, yield, and type of the plant from which the fruit came will not result in much improvement, for even poor plants may produce a few good fruits. There is generally no hereditary differences in seed from early or late fruit, or from large or small fruits on the same plant.

Generally speaking, the ideals in selecting tomatoes are: first, a vine that is large, vigorous, free from all disease, and producing a large yield of fruit at the season when they are particularly wanted; second, fruits that are of the size, color and shape desired for the variety; third, fruits which are smooth in contour, and free of defects such as corky spots, large scabs or "cat-faces." When cut transversely, they should show well-filled cells and freedom from greenish spots and hard white cores.

Fruit from which seed is to be saved should be allowed to ripen fully on the vine. When large quantities are to be saved from a number of plants, the ripe fruit is gathered at intervals and dumped into wooden barrels, where it is pounded into a pulp, or the fruit may be pulped by pressing through a grinder. Water should not be added—there will be sufficient juice in the pulp to insure speedy fermentation. After standing until the gelatinous mass surrounding the seed is well decomposed, water is added. Vigorous stirring facilitates separation of the seed. The good seed sinks to the bottom while the light seeds, skins, and pulp rise to the surface, where they can be removed easily. Several successive washings clean the seed thoroughly, after which they should be drained, spread in thin layers on wire or cloth screens, and placed in the sun or elsewhere to dry as quickly as possible.

In cleaning seed on a larger scale, a flume with catch basins is used to separate seed from pulp, and the seed is dried in rotating cylinders through which a current of hot air is driven.

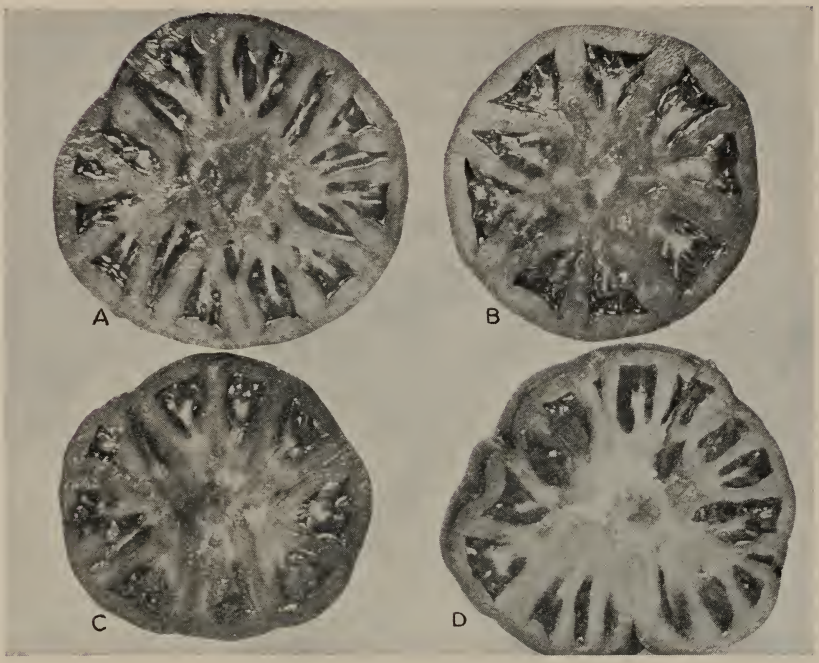

Fig. 18.—Cross sections of fruit of the San Jose Canner variety. *A*, large meaty core with small cells—a good type. *B*, cells too large—a poor type. *C*, many abortive cells, characteristic of rough fruit—a poor type. *D*, large hard white core in center of fruit. (From Hilgardia, vol. 2, no. 2.)

Fig. 19.—"Puffy" fruit. Note the air spaces between the seed jelly and the outer wall. This trouble is partly a hereditary variety characteristic, and is partly due to cultural conditions. (From Hilgardia, vol. 2, no. 2.)

DISEASES OF TOMATOES

Damping Off.—This is a trouble which attacks tomatoes and other plants while growing in seed beds. It is due to various fungi which are often present in soils. These fungi attack the plants at the surface of the soil, causing the stem to shrivel and turn black, while the top

Fig. 20.—Damping off of tomato seedlings. Note that the lower part of the stem is shrivelled and blackened. (From Agr. Exp. Sta. Bul. 239.)

soon falls over (fig. 20). This disease is most likely to do serious damage when the same soil is used year after year for plant beds. It is also likely to spread rapidly when the surface of the soil is kept damp continually. Preventive measures are: using fresh soil in the plant beds each year; watering plants only when absolutely necessary and

then always in the forenoon so that plants and soil surface may dry before night; ventilating the plant beds as freely as possible if they are covered; and avoiding overcrowding of plants by transplanting to proper distance or by thinning. The further development of the disease, when it appears, can be prevented by sprinkling the surface of the soil with a ¼ of 1 per cent solution of Semesan. This is an organic mercury preparation which can be applied to growing plants without injury.

Fig. 21.—Late blight infection on tomato leaf.
(From Agr. Exp. Sta. Bul. 239.)

Late Blight.—This fungous disease often appears in coastal districts on potatoes and tomatoes. It spreads only in moist cool weather. In southern California the fall and winter crop is very seriously injured by this disease, especially when the rains come earlier than usual. Due to its irregular appearance, growers are seldom prepared to combat it, hence serious damage results. The effects of the disease appear, soon after the rains commence, in the form of numerous black spots on leaves and stems (fig. 21). The leaves then turn yellow and

wither or fall off. If the weather remains moist, the whole plant soon blackens and dies. The fruit is also affected. Green fruit shows slightly depressed and discolored patches resembling a bruise, and these places develop into a soft decay (fig. 22). When late blight is prevalent, fruit which shows no visible evidence of infection at the time it is picked may develop the disease during shipment, to a serious extent.

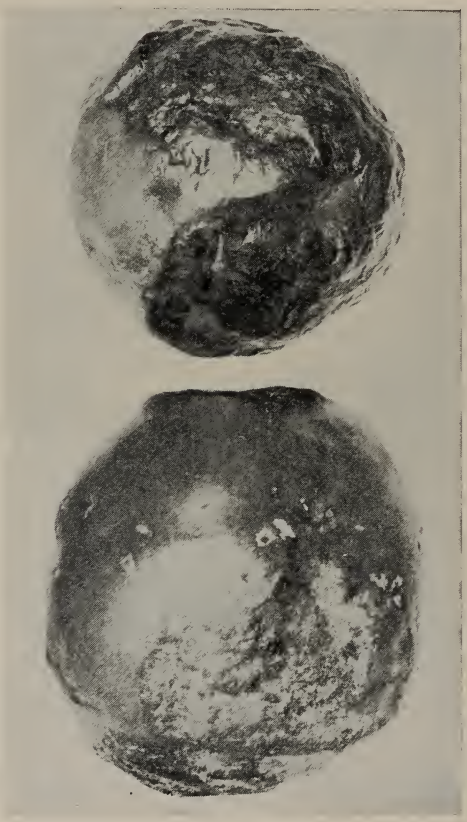

Fig. 22.—Late blight injury to tomato fruit, in advanced stages of infection. (From Agr. Exp. Sta. Bul. 239.)

Late blight can be prevented by spraying the plants thoroughly with Bordeaux mixture whenever early rains occur and the disease threatens. The spray material is prepared by dissolving separately, 4 pounds of copper sulfate (bluestone) and 4 pounds of unslaked lime (or 6 pounds of hydrated lime). Each solution is diluted to 25 gallons and the two are then poured together, making 50 gallons of the spray material. Special spraying machines adapted for spraying two or three rows at a time are used. They should have three

nozzles for each row. Tomatoes should be sprayed at a pressure of at least 100 pounds per square inch, to insure that all parts of the plant are reached by the spray. Several applications of the spray are necessary to keep the new growth of the plants protected from infection. Orchard power sprayers can be used also to spray the tomato fields. The amount of spray solution required for each application will vary from 100 to 300 gallons per acre, depending on the size of the plants and the width of the rows.

Fig. 23.—A plant showing early stages of Fusarium wilt. The tips of certain branches are wilting and the lower leaves are yellow.

Fusarium Wilt.—This disease is caused by a specific fungus living in the soil. It occurs to an injurious extent in many parts of southern California and to a lesser degree elsewhere. When the disease once gets into a field, the soil remains infected and it spreads rapidy in succeeding years. However, the Fusarium wilt organism of tomato attacks no other crop. The disease usually appears a few weeks after the beginning of hot weather, the lower leaves of affected plants turn yellow and dry up (figs. 23 and 24). The stems, if split open, are found to be brown in the woody portion. The disease advances rapidly and kills the entire plant, or only some of the main branches. There is seldom a true wilting of the whole plant, in the ordinary sense of the word, connected with this disease. The fungus enters the plant through the roots and progresses upward through the plant, which is killed by a toxin excreted by the fungus. Plants affected early in the season are killed outright, while those affected later may produce a

few small tomatoes. The control is to grow resistant varieties, of which the Norton seems best at present, though Marglobe, an early variety, may be more desirable in some cases. Some strains of the San Jose Canner are also resistant. Rotation of crops, growing the tomatoes on non-infected soil, is also a means of prevention. Even when resistant varieties are grown, the plant beds must be on non-infected soil.

Fig. 24.—Tomato plant in advanced stages of Fusarium wilt. (From. Agr. Exp. Sta. Bul. 239.)

Verticillium Wilt.—In many respects, the disease caused by Verticillium resembles the Fusarium wilt. However, Verticillium occurs chiefly in the cooler districts, as the San Francisco Bay region, while Fusarium is more common in warmer sections. Verticillium disease is of much more general importance than Fusarium, for it attacks many other crops besides tomatoes. There is no control known for Verticillium, except rotation with non-susceptible crops, such as the cereals. Land that is known to be infected should be avoided for tomato production.

Root-Knot.—This trouble is caused by nematodes—microscopic worms which infest the soil and which enter the roots of tomatoes and many other plants, causing a swelling of the roots (fig. 25). Affected plants may die suddenly, but generally appear stunted and yellowed, and die slowly. The trouble can always be recognized by pulling up the plants and inspecting the roots. Extreme caution should be exercised by growers to prevent the introduction of the disease on vegetable plants or seed potatoes shipped from other sections. When

once introduced into the soil, nematodes are very difficult to eradicate. Continuous flooding of the land for two or three months, thorough drying out of the soil over summer, summer fallow, and growing resistant crops for two years are practices that have been recom-

Fig. 25.—Roots of tomato plant affected by nematodes—the root-knot disease. (From Agr. Exp. Sta. Cir. 280.)

mended. The small grains, the Iron variety of cowpea, and the velvet bean are some of the crops resistant to nematodes. The danger of nematodes is greatest on sandy soils. One should always make sure that the soil used for plant beds is free from nematodes, for infected beds are often responsible for infecting the plants and spreading the trouble.

Mosaic.—This disease causes a mottled and somewhat distorted appearance of the leaves; the plants are stunted and do not produce much fruit, though they may survive. The disease is of the virus type, and is spread in the field by insects, especially the aphis, and by the hands of workers who prune and tie staked plants. Infected plants should be promptly pulled up and burned or buried to prevent the spread of infection. Probably the most important step in controlling the disease is to destroy the perennial weeds related to tomatoes, on which the disease over-winters. Horse nettles, ground cherries, and matrimony vine especially should be eliminated from the neighborhood of the plant beds and from the field as well, if possible. The disease is not transmitted on the seed, nor is spraying effective in control.

Streak.—This disease is said to be caused by double infection of the plants with the virus of tomato mosaic and potato mosaic. The leaves at first show the mottling and distortion characteristic of tomato mosaic, then develop numerous brown spots. These spots also appear on the tips of the stems. The plants are stunted and die from the top downward. The green and ripe fruit are also affected, showing raised greasy-brown patches. Streak occasionally occurs almost everywhere that tomatoes are grown in California, sometimes in destructive amounts. It is most prevalent in the fall and winter crop of the southern coastal districts. The control is the same as for mosaic. Tomatoes should not be grown after potatoes, for the volunteer potato plants which usually are quite numerous the year after potatoes are grown, would be a source of mosaic infection to the tomato plants.

Tomato Yellows.—This disease has in the past been referred to as summer blight, yellow blight, and western yellow blight. It is a virus disease, caused by the same virus that causes the curly-top disease in beets, and which also attacks numerous other crop plants (fig. 26). It is transmitted to the tomato plants by the beet leafhopper, a small active sucking insect. In most sections of California the yellows disease does not occur every year in epidemic form. It is severe only in years in which the leafhoppers are very numerous. Yellows occurs most commonly in the warm interior valleys, where in some years the tomato crop is wiped out.

Affected plants stop growing, the leaf margins roll upward, the leaf blades become yellowish and the veins on the underside of the leaf, as well as the stems, become purple (fig. 27 and 28). The plants usually die within a few weeks if they become infected while young, while older plants may produce a few inferior fruits. The disease is not seed-transmitted, nor is it much affected by soil or cultural con-

ditions. Slight shading of the plants protects them to a certain extent, and it may be possible to combine tomatoes with a tall-growing shade crop, like sunflowers. Also, thick planting, either by having two or three plants, in each hill, or by having the plants spaced much closer together than usual, gives some protection. The excess number of plants will result in a fair crop, even though a high percentage of them are killed by yellows. Late planting will in some cases also allow the tomatoes to escape yellows. The Dwarf Champion and other dwarf varieties, as well as the little Red Pear, are somewhat resistant to yellows.

Fig. 26.—Proof that the yellows disease is carried by beet leafhoppers. Row 3 had its plants exposed to infective hoppers for three days before transplanting. Rows 2 and 4, checks, remained almost entirely healthy. (Courtesy of H. H. Severin.)

Blossom-end Rot.—The damage done by this disease varies much, according to the season and soil conditions. The first stage occurs on either green or ripening fruits, as an irregular brownish patch at the blossom-end. If the trouble does not develop beyond this stage, as is sometimes the case, little harm is done. But generally the disease advances rapidly, developing a black dry leathery rot which may advance until half of the fruit is decayed (fig. 29). The disease is usually associated with drought conditions, where the plants are not able, on account of dry soil or limited root systems, to take up moisture as fast as it is needed. It also occurs where the plants have made an excessively rank growth of vines early in the season, and are then checked by insufficient moisture when the fruit is ripening. Blossom-end rot also often occurs when tomatoes are grown on soils of high salt concentration, or "alkali." The prevention of this disease seems to lie in proper regulation of the moisture supply. The development of a deep root system by the plant will also aid in preventing disease.

Failure to Set Fruit.—This is a frequent cause of trouble, especially at certain seasons of the year. Although the plants may bloom profusely, the flowers may fall without setting fruit. One frequent cause of the trouble lies in the excessively rank vegetative growth of the plant, which is likely to occur when the water supply is too liberal or when the soil is excessively rich in nitrogenous matter. Another cause is the very low humidity of the air which often occurs in summer. This condition, in connection with high temperature and high winds, may cause most of the blossoms to fall.

Fig. 27.—Leaves from tomato plant affected with tomato yellows. Note the rolling of the leaves. This affects all parts of the plant. (From Agr. Exp. Sta. Bul. 239.)

Avoiding too much nitrogenous fertilizer and irrigating sparingly if at all during the first bloom stage, will promote a better set of fruits. Windbreaks and the selection of a type of plant having heavy foliage will be helpful in other cases.

INSECT PESTS

Tobacco Horn Worm.—The caterpillars of this insect are from two to three inches long when full grown (larval stage) and are pale green in color. They are voracious feeders and defoliate the tops of the branches rapidly. They also attack the green fruit. The first brood

of these insects appears about mid-summer; they rapidly increase in number throughout the season. Hand-picking may be the most economical way to dispose of the small numbers appearing at first. As soon as they become numerous, resort should be had to spraying with arsenicals. Probably the most effective treatment is to spray the plants with arsenate of lead, 4 pounds to 100 gallons of water. For

Fig. 28.—Tomato plant showing advanced stage of the yellows disease. (From Agr. Exp. Sta. Circ. 280.)

small acreages, a double-action hand-pump, mounted on a sled with a 50- or 100-gallon tank, may be used. With a short lead of hose and an 8-foot rod, it is possible to spray four rows at each trip through the field. Usually the spraying has to be repeated often.

Late in the season, when the plants almost completely cover the surface, spraying becomes impracticable, and dusting with a mixture of 1 pound of arsenate of lead to 20 pounds of slaked lime, is effective. Airplanes have been used to dust large acreages.

Fall or winter plowing of land which has been in tomatoes, will expose and destroy many of the pupae, thus reducing the number of insects the following year. They pupate in the soil near the plants on which the larvae fed.

Tomato Fruit Worm.—This is the same insect as the corn earworm. The larvae are brown-stripped and are about one inch long when full grown. The adult moths lay their eggs on the foliage, and the young larvae, after feeding a time on the leaves, bore into the green fruit. After the larvae have fed within the fruit for a time, the fruit is made unfit for market, and if moist conditions prevail, the punctured fruits are often destroyed by a soft rot. The tomato fruit worm is prevalent particularly in the interior valleys. Control

Fig. 29.—Tomatoes showing blossom-end rot in different stages of development. (From Agr. Exp. Sta. Bul. 239.)

measures are crop rotation and spraying or dusting as for the tobacco horn worm. In fact, the same program of treatment will control both insects, although the control of the tomato fruit worm will not be so nearly complete as it is for the tobacco horn worm. When spraying tomatoes with arsenicals for control of fruit worm, a spreader and sticker, such as Kayso, should be added to the spray solution.

Trapping the worms on corn planted between the tomatoes has been recommended, but this simply leads to increased number of worms in the later broods, unless the corn, with its worms, is destroyed. Since the moth which lays the eggs of the fruit worm is a night flyer, light-trapping has also been suggested. However, it is found that the female moths are not much attracted by the lights until after they have completed their egg laying.

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